1000

No vertical exaggeration

EXPLANATIO

where concealed. Bar and ball on downthrown

Thrust fault--Sawteeth on upper plate; dotted where

Anticline--Showing trace of axial plane; dashed where

Syncline--Showing trace of axial plane; dashed where

Strike and dip of flow bands and eutaxitic structures

approximately located; dotted where concealed

approximately located; dotted were concealed

side. Single arrows indicate apparent relative

lateral movement. Arrow and degrees indicate

undetermined offset

Strike and dip of beds

Inclined

Overturned

Estimated

Inclined

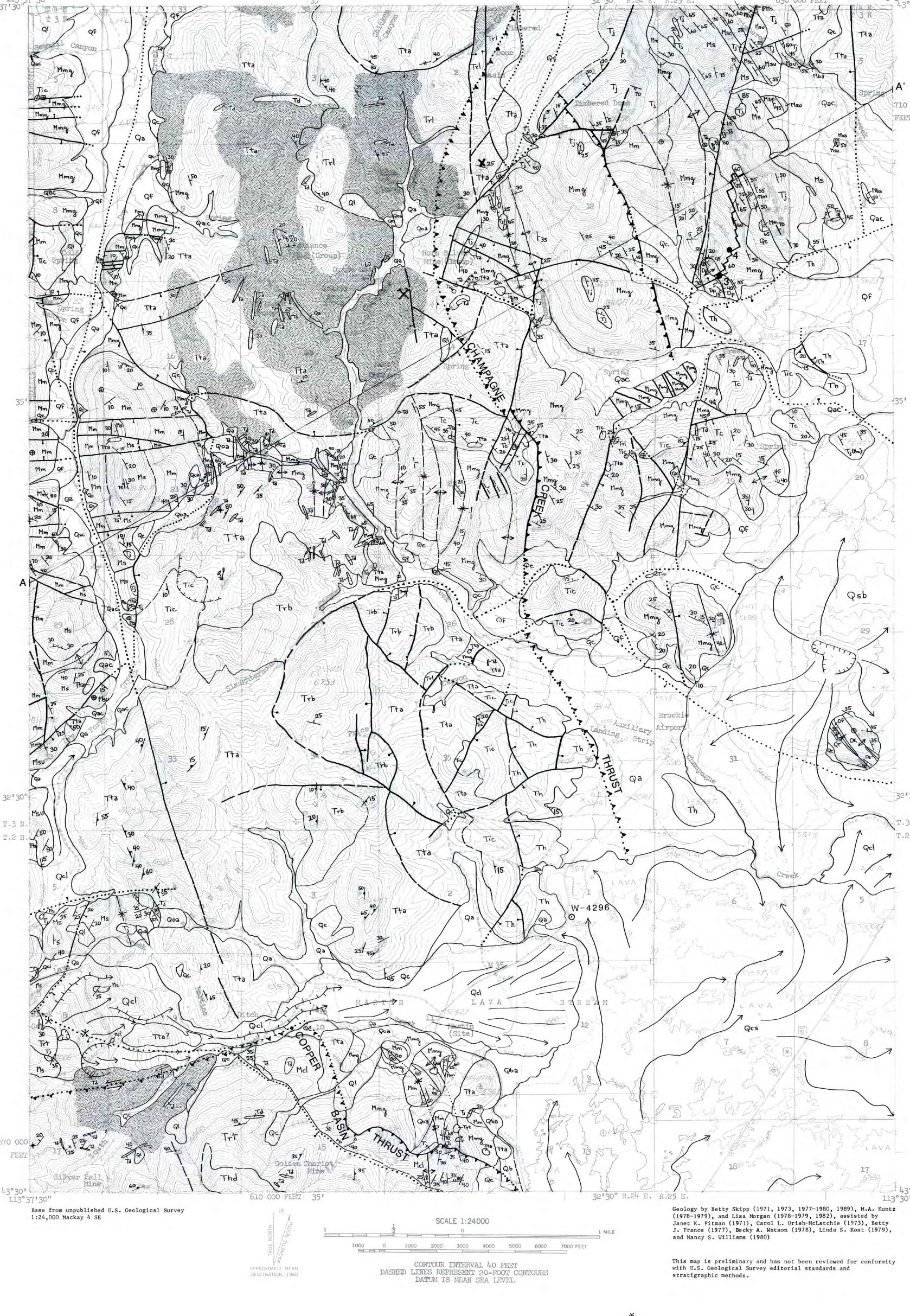
Vertical

Horizontal

Fault-Dashed where approximately located; dotted

observed dip of fault plane

Photo lineament--Probable fault or fracture with



DESCRIPTION OF MAP UNITS SURFICIAL DEPOSITS

Alluvium (Holocene) -- Unconsolidated, poorly sorted deposits of fluvial gravel, sand, silt, and clay along present drainage systems. Maximum thickness Travertine (Holocene) -- Very light gray, finely crystalline, banded limestone in one small outcrop along south- eastern margin of quadrangle on block of Paleozoic quartzite and dolomite foundered in Colluvium (Holocene and Pleistocene) -- Unconsolidated accumulations of soil and rock fragments that mantle the land surface and obscure bedrock;

locally includes talus and frost rubble.

Deposited by mass wasting processes. Maximum

thickness several tens of feet Alluvium, and colluvium undifferentiated (Holocene and Alluvial-fan deposits (Holocene and Pleistocene)--Fanshaped deposits of unconsolidated alluvial gravel, sand, and silt. Maximum thickness several tens of Landslide deposits (Holocene and Pleistocene) -- Local accumulations of unconsolidated and partly consolidated rubble composed of coarse, mostly angular, debris derived by gravitational sliding from nearby bedrock and surficial deposits. Maximum thickness several tens of feet Basaltic ash and alluvium (Holocene and Pleistocene)-

Moderate-reddish-brown-weathering, black ridescent basaltic ash and cinders mixed with alluvium at the mouth of Lava Creek Basaltic ash (latest Pleistocene) -- Unconsolidated moderate-reddish-brown-weathering, black iridescent basaltic ash and cinders underlying the west margin of the Sunset pahoehoe basalt flows. Well-bedded exposures present in several borrow pits just south of the quadrangle (Sidle, 1979) where ash is excavated for road metal. Maximum exposed thickness about 10 ft LAVA FLOWS AND RELATED VENT DEPOSITS

OF THE CRATERS OF THE

MOON LAVA FIELD

Sunset pahoehoe basalt flows (latest Pleistocene)--Chiefly surface- and tube(?)-fed pahoehoe flows from source vents at Sunset Cone cinder cone which is located about 2.5 mi (4 km) directly south of the Golden Chariot mine. Only medial and distal parts of the Sunset flows occur in this quadrangle. Sunset Cone and proximal parts of the Sunset flows are shown on a map of the adjacent Inferno Cone quadrangle (Kuntz and others, 1989). Flows are medium-dark-gray and hummocky. Pressure ridges, pressure plateaus, and collapse depressions, indicative of high-volume, shortduration eruptions, are characteristic of Sunset flows in this quadrangle. Minor amounts of a a lava occur where pahoehoe flows collapsed or move over steep slopes after initial cooling. Rock is hypocrystalline and porphyritic: contains microphenocrysts of euhedral olivine (Fo₆₀) plagioclase laths (An45), and titanomagnetite set in an intergranular matrix of the same minerals plus blades and patches of spindly augite and brown glass charged with tiny opaque minerals. Age of unit, based on radiocarbon analysis of harred, carbon-bearing soil obtained from a backhoe excavation beneath flow in SW1/4, sec. 1 T. 2 N., R. 24 E. (lab no. W-4296 in Kuntz and others, 1986; Kuntz and others, 1988) is

12.010+150 vr B.P. Lava Creek a'a and pahoehoe basalt flows and associated cinder deposits (latest Pleistocene)-Chiefly surface and channel-fed, dark gray, blocky, a'a basalt flows. Source vents for flows in Lava Creek are at Black Cap cinder cone. The small lobe of a'a that moved north into the valley of Dry Fork Creek was fed from small cinder cone vents that lie northwest of Black Cap cinder cone in the adjacent Mackay 4 (Grouse) SW quadrangle (Skipp and Bollmann, in press). Both Black Cap and the vents northwest of it are aligned in a N. 30° W. direction, parallel to and an extension of the Great Rift volcanic rift zone in Craters of the Moon National Monument (Kuntz and others, 1988). Black Cap cinder cone consists chiefly of black cinders, agglutinated spatter, bombs, lapilli, coarse ash, and interlayered, thin flows. Red and brown cinders and ash locally mantle black tephra on Black Cap cinder cone. Thin sheets of shelly pahoehoe occur on and aroun Black Cap. The major lobe of Lava Creek flows was fed from a vent at base of east slope of Black Ca cinder cone and flowed east onto the Snake River Plain. Long. deep channels occur in the narrow. medial part of the main lobe 0.6-3.1 mi (1-3 km east of Black Cap. Flow contains conspicuous flow ridges that are perpendicular and convex to direction of flow movement; longitudinal furrows and cracks are roughly parallel to flow movement. Rock is chiefly hypocrystalline, partly diktytaxitic, and microporphyritic to porphyritic. In porphyritic rocks, single euhedral crystals and clots of several crystals of olivine (Fo₅₅), euhedral laths of plagioclase (An, 5), and titanomagnetite are all as long as 1.2 mm in longest dimension. The matrix is typically a granular agregate of olivine, itanomagnetite, ilmenite, rare blades of augite less than 0.1 mm long, plagioclase laths that are 0.1-0.2 mm long, and brown glass containing ubiquitous small crystals of opaque minerals. Inclusions of dacitic volcanic rocks are common in hand specimens and thin sections. The oldest of two radiocarbon analyses of carbon-bearing sediment obtained from beneath the flow in a backhoe excavation located approximately 6.2 mi (10 km) north- east of this quadrangle is

LAVA FLOWS AND RELATED DEPOSITS OF THE SNAKE RIVER GROUP

others, 1986; 1988)

12,760+150 yr B.P. (site W-4476 in Kuntz and

Pahoehoe basalt flows and shield volcano (Pleistocene) -- Typically brownish-gray to darkgray, slightly weathered pahoehoe basalt flows. nit locally covered by discontinuous deposits of loess and eolian sand as deep as several meters. Flows were erupted from small shield volcano in SW 1/4, sec. 29, T. 3 N., R. 25 E. Vent is shallow depression, largely filled with eolian sand, about 600 m in longest dimension. Vent is elongated N. 60° W., roughly parallel to orientation of feeder fissure for vent. Rock is commonly hypocrystalline, diktytaxitic, and porphyritic to aphyric. Crystals of olivine and plagioclase are as large as 1-4 mm. Plagioclase, olivine, augite, itanomagnetite, and ilmenite constitute the matrix and have a size range of 0.1-1.0 mm. Brown glass is charged with tiny crystals of opaque

SILICIFIED ROCK

Jasperoid (Eocene or younger Tertiary) -- Light-gray to black and medium-brownish-gray, aphanitic to finegrained "silica rock" formed by alteration of Paleozoic rocks and, on Timbered Dome, conglomerates of unit Tc: commonly brecciated: sedimentary structures and fossils preserved le cally; weathers light to moderate brown, brownishgray, and gray to black; wind polished surfaces common; a gradational contact 1 or 2 m wide, with unsilicified Paleozoic bedrock host is common. Rock forms ledges and ridges; maximum thickness 300-400 ft in Timbered Dome area

ROCKS OF HEISE VOLCANIC FIELD

Túffs of Blue Creek and Blacktail, undivided (Miocene) -- Grayish-purple, pale-red, light-brown and light-gray densely welded rhyolite ash-flow tuffs containing lithophysal zones and black, locally spherulitic, vitrophyres. The tuff of Blue Creek is a crystal-poor simple cooling unit naving less than 2 percent small (most less than mm) phenocrysts of chiefly sodic plagioclase and lesser amounts of quartz, sanidine, augite, and magnetite; the tuff has a fission-track age of 6 Ma, and a whole-rock K-Ar age of 6.0+0.2 Ma (R.F. Marvin, written commun., 1986). It is conformable above the tuff of Blacktail (Morgan and others, 1984). The tuff of Blue Creek has an estimated thickness of 30 ft at one locality (SW 1/4 sec. 8, T. 3 N., R. 25 E.). The tuff of

Blacktail is a crystal-rich simple cooling unit that contains 5-16 percent relatively large phenocrysts, as much as 4 mm in length, of sodic plagioclase, quartz, sanidine, magnetite, augite, and orthopyroxene, in addition to common pumice and lithic fragments; the tuff has a zircon microphenocryst fission-track age of 6.5 Ma (Morgan and others, 1984) and a K-Ar age on sanidine of 6.7+0.2 (Kellogg and Marvin, 1988) The tuff has a minimum thickness of 80 ft in the quadrangle. Both tuffs have normal magnetic

remnant directions. These ash flow remnants are

the westernmost recognized fragments of the Heise

volcanic field north of the Snake River Plain

where they were deposited against the faulted

margin of the Snake River Plain downwarp IDAVADA GROUP

Tuffs of Little Chokecherry Canyon (Miocene and Miocene(?))--Light-brownish-gray, grayish-redpurple, and light-olive-gray, densely welded, partly devitrified, rhyolite ash-flow tuffs comprising several cooling units consisting of at least two distinct lithologies. One lithology consists of 5-10 percent crystals of plagioclase sanidine, quartz, augite, and opaque minerals in a shard-rich matrix that contains a few pumice fragments. The second lithology consists of up to Tqm 20 percent crystals of feldspar, biotite, and quartz in a glassy matrix that also contains pumice fragments. Vesicular zones are common in both lithologies, and individual elongated vesicles are as much as 12 in. (30 cm) long and 3 in. (7 cm) high. Tuffs weather brownish gray, grayish red purple, and olive gray. Common medium-dark-gray to black vitrophyres are por-phyritic and perlitic in places. An Ar⁴⁰-Ar³⁹ on sanidine from outcrop of augite-bearing rhyolite tuff about 5 mi north of this quadrang is 9.41+.04 Ma (written commun., F.J. Moye and L.W. Snee, 1988) or Miocene. The biotite-rich tuffs that outcrop along Dry Fork are not dated and may be older than Miocene. Minimum thickness of unit about 200 ft

[Relative age relations of units are based

CHALLIS GROUP (EOCENE)

primarily on field evidence] Dikes--Light- to medium-gray and light- to mediumbrownish-gray porphyritic rhyolite containing 5-25 percent small (0.25 mm) to large (5 mm) phenocrysts of commonly twinned euhedral to subhedral plagioclase, largely oligoclase. Also contains phenocrysts of sanidine and anhedral, partly resorbed, commonly smoky, quartz. Plagioclase and quartz phenocrysts are present in all dikes and sanidine phenocrysts, locally as long as 2.5 cm (centimeters), are present in most dikes. The large phenocrysts of plagioclase, Sanidine, and quartz and subordinate smaller partly chloritized, rare phenocrysts of biotite, amphibole, and clinopyroxene are present in a fine- to medium-grained groundmass composed largely of potassium feldspar and quartz. Xenoliths of sedimentary rocks are rare. The rhyolite weathers yellowish gray, light orange light greenish gray, and light to medium brownis gray. Chilled, black glassy margins of dikes, brecciated in places, are present locally. Included in this unit is a white to yellowish gray opaline intrusive body about 1/2 mi east of the Champagne Mine that contains anhedral quartz phenocrysts commonly 1 mm in diameter. Dikes form resistant ridges that trend chiefly east-west and north-south in the quadrangle. A dominant trend for the dikes to the north of the quadrangle is N. 70°-85° E. (Skipp, 1988, 1989). These dikes intrude all other Challis volcanic units in the Granitic plutonic rocks undivided (Eocene)--Ouartz

area. They are the youngest recognized product of the Challis magmatic event (Nelson and Ross, 1968, monzonite (unit Tqm), hornblende diorite of Little To Cottonwood Creek (unit Thd), and other buried granitic rocks thought to intrude Paleozoi sedimentary rocks and volcanic rocks of the Challis Group in the vicinity of the Lava Creek Mining District. Hornblende diorite of Little Cottonwood Creek

(Eocene) -- Greenish-gray and light-gray, coarsegrained porphyritic diorite composed of 50 percent or more sericitized plagioclase phenocrysts up to 2.5 mm in length, largely unaltered augite crystals, chloritized biotite pseudomorphs after hornblende and pyroxene, and magnetite in a matrix of quartz, feldspar, and epidote. Petrographic description is based on one sample from stock along south border of quadrangle. Anderson (1929, p. 23) described this northern end of the stock as having the composition and texture of a granophyre. The main body of the stock south of the quadrangle has been described as a porphyritic hornblende granite (Anderson, 1929, p. 24) and as a hornblende quartz monzonite (Sidle, 1979, p. 31-32), and has been called hornblende quartz monzonite (unit Tam) by Kuntz and others (1989). An andesite pipe that intrudes unit Tta 1 mi north of the quadrangle border closely resembles this stock (Skipp, 1988). The stock intrudes rhyodacite tuff breccias (unit Trt), and is cut by granite pegmatite dikes (not shown) compositionally similar to the rhyolite dikes of unit Td (Sidle, 1979)

Rhyodacite tuff breccia, tuff, and lava flows--Chiefly grayish-green to greenish-gray, gray, or lightyellowish-gray, heterolithologic tuff breccias containing lenses of white non-brecciated bedded crystal-vitric tuff, and interbedded dark gray lava flows that weather greenish gray, brownish gray, and light-brownish gray. Tuff breccias contain an average 65 percent of subangular lithic fragments of porphyritic rhyodacite and pumice that average 2 in. (45 mm) in diameter, and an average 23 percent crystals of potassium-feldspar, plagioclase, biotite, and hornblende in a finegrained, partly devitrified, chloritic glassy matrix. Non-brecciated bedded tuff interbeds contain an average of 40 percent crystals of potassium-feldspar and quartz and lesser amounts of plagioclase, biotite, hornblende and opaque iron oxides, and 20 percent lithic fragments, including pumice, in a dark-brown glassy matrix. Lava flows are porphyritic hornblende-biotite rhyodacites containing 45-60 percent phenocrysts of kaolinized orthoclase, anhedral quartz, anhedral sodic plagioclase, partly sericitized and chloritized, and hornblende, biotite, and opaque iron oxides in a finely crystalline matrix of feldspar and quartz. Unit includes units Tcv3, cv4, and Tcv5 of Sidle (1979) and units Tclb and Tctb of Kuntz and others (1989) with an aggregate thickness of about 2,700 ft. Petrographic descriptions and thickness from Sidle (1979) This unit dips generally north and east and is present only in the southwestern part of the quadrangle where it is dominantly light-colored due to argillic alteration that cuts across all lithologies. Stratigraphic relationship of unit to other Challis Group units other than Td and Thd is not clear. The tuff breccia is overlain uncon formably by an ash flow tuff about 1/4 mi south of the quadrangle boundary (Sidle, 1979; Kuntz and others, 1989) that tentatively is correlated with

places. Darker limestone beds have fetid odor. Limestone is medium- to thick-bedded, cliffforming, locally cavernous. Black and light-gray chert in thin stringers and nodules comprise up to the tuff of Stoddard Gulch (Skipp, 1988, 1989). 5 percent of some beds in upper part, and thin Rocks of the unit were deposited against faulted beds and nodules of yellowish-brown-weathering Mississippian rocks and volcanic rocks assigned to incipient chert make up as much as 30 percent of the tuff of Antelope Creek (Tta) some lower beds. Some silty beds are present in Rhyodacite breccia unit (Eocene) -- Medium-dark-gray to middle part. Thin silty and argillaceous grayish-black, and light-grayish-purple limestone partings in upper part weather yellowish eterolithologic breccia containing glassy and gray and grayish red. Phosphatic nodules and stony angular to subangular fragments up to 5 ft brachiopods are present in uppermost 30 ft near in diameter of porphyritic biotite and porphyritic Timbered Dome. Limestone is typically fossilpyroxene rhyodacite. Blocks and fragments are set iferous medium- to coarse-grained wackestone with in a light-gray to light-grayish-purple tuffaceous lesser mudstone and packstone. Fossils include matrix; matrix erodes easily from between angular algae, brachiopods, bryozoa, conodonts, corals, rock fragments. Unit weathers dark gray and crinoids and echinoids, foraminifers, mollusks, moderate brown. Possibly a vent breccia. Breccia ostracodes, and trilobites that indicate a Late present locally above tuffs of Antelope Creek Mississippian (Chesterian) age (Skipp, 1961; Tta) in Champagne Creek area. Thickness 0 to Nelson and Ross, 1970). Conodont CAI values from greater than 300 ft. Top not exposed. limestones near top of formation at Timbered Dome Stratigraphic position believed similar to rhyoare 2-2 1/2 (Skipp, 1988). Basal contact is gradational with South Creek Formation below.

> Thickness determined from map pattern is about South Creek Formation (Upper Mississippian) -- Mediumto medium-dark-gray, chiefly thin-bedded, silty, fine-grained limestone that weathers light gray, and contains scattered nodules of yellowish-brownweathering partly silicified incipient chert. Formation is poorly exposed, forms a valley between surrounding cliff-forming units, and is locally altered to jasperoid. A sparse fauna of brachiopods, bryozoa, pelmatazoan debris, a few corals and foraminifers in calcareous mudstones and wackestones indicate a Chesterian age. Basal contact gradational with underlying Scott Peak Formation. Estimated thickness in northeast part of quadrangle is 360 ft

Scott Peak Formation (Upper Mississippian) -- Medium- to medium-dark-gray, light- to medium-grayweathering, chiefly pure, variably cherty, fossiliferous, thin- to thick-bedded, cliff-forming, locally cavernous limestone that is altered to jasperoid on east flank of Timbered Dome. Some silty limestone beds are present, and yellowishbrown-weathering, incipient chert nodules and lenses are common in lower part. Black to lightgray chert in lenses and nodules are scattered throughout but make up as much as 50 percent of some beds in the middle part. Limestone is fossiliferous, fine- to coarse-grained wackestone packstone, and grainstone with lesser mudstone and boundstone. The abundantly fossiliferous upper two-thirds of unit contains algae, brachiopods, bryozoa, conodonts, corals, echinoids, foraminifers, mollusks, ostracodes, pelmatazoa trilobites, and a few shark teeth that indicate a Late Mississippian (Meramecian and Chesterian) age (Skipp, 1961; Nelson and Ross, 1970). Basal contact is abrupt and conformable or gradational. Estimated thickness in northeastern part of quadrangle is about 1,600 ft Middle Canyon Formation (Upper Mississippian) -- Mediumgray to grayish-black, thin- to medium-bedded,

Rhyodacite lava flows--Grayish-red-purple, pale-red-

gray to grayish-black, porphyritic to

purple, greenish-gray, brownish-gray, and medium-

glomeroporphyritic rhyodacite and quartz latite

lava flows. Flows contain 10-30 percent crystals

of plagioclase, pyroxene, hornblende, biotite, and

minor potassium feldspar and quartz. Xenoliths of

underlying volcanic units, argillite, quartzite,

and granitic gneiss locally are rare. Groundmass

of rhyodacite is a very fine to fine-grained

mosaic of plagioclase, quartz, opaque minerals

locally is brecciated. Lavas weather dark

and potassium feldspar. Chilled glassy margins

yellowish brown, moderate brown, and grayish red

has reversed magnetic polarity (Skipp, 1988).

Lava flows form cliffs and irregular knobs.

at the divide above Hammond Spring Creek.

Quartz monzonite porphyry (Eocene) -- Olive-gray and

Monzonite is composed of about 45 percent

monzonite that weathers light brown and gray.

phenocrysts as much as 6 mm in length of glassy

ilmenite. All phenocrysts are corroded and

of Hammond Spring Creek near the fault between

unit Tcal of the Challis Group and the McGowan

Group where it is sericitized. Petrographic

Anderson (1947) -- Mostly andesitic to rhyodacitie

shflow tuffs, airfall tuffs, thin interbedded

sandstone, conglomerate, and breccia. A poorly

mapped by Anderson (1947) between Champagne and

Lava Creeks is included in this unit; the fine-

grained nature of the intrusive rock makes it

difficult to distinguish from volcanic rocks.

Crystal-rich welded ash-flow tuffs are gray.

the lower tuffs and plagioclase, pyroxene,

upper and lower tuffs contain opaque oxide

minerals, some sanidine, minor quartz, and

accessary apatite in a glassy or devitrified

gray and yellowish gray. Interbedded light-

colored air-fall tuffs commonly are biotite

volcanic lithic fragments that are similar to

argillic alteration is present in much of the

unit, and secondary sericite, silica, chlorite,

actinolite, and calcite are common. Densely

0 to about 2 000 ft. K-Ar age determined on

biotite from tuff of this unit is 47.6+2.1 Ma

Basal conglomerate, breccia, and sandstone--Light

are found in this unit.

(R.F. Marvin, written commun., 1982). The majo

ore deposits of the Champagne Creek subdistrict

colored, poorly to moderately well-consolidated,

boulder to granule conglomerate and breccia con-

taining lenses of fine-grained to conglomeratic

sandstone. Conglomerate and breccia clasts, as

than 4 in. (10 cm), of locally derived quartzite,

granule conglomerate, sandstone, chert, siltstone,

sandstone or grayish-red mudstone. Matrix locally

supported fabrics are common. Sandstone lenses

are thin, as much as 3 ft thick, and make up less

and locally cross bedded, and weathers moderate

brown. Outcrops probably are remnants of Eocen-

alluvial fans (Paull, 1974; Burton and Blakley,

1988). Local imbrication of pebbles in N1/2 sec.

19, R. 25 E., T. 3 N. indicates southeastern flow

Challis Group. Thickness ranges from 0 to about

Pennsylvanian to Upper Mississippian) -- Light-gray

to grayish-black, mostly medium- to dark-gray,

interbedded light-gray, very fine grained

include brachiopods, bryozoans, corals,

mi north of the quadrangle (Skipp, 1988)

chiefly impure, fos siliferous, variably cherty

calcareous sandstone and siltstone. Limestone.

commonly sandy, is thick to thin bedded. Faunas

foraminifers, and mollusks that indicate a Late

Pennsylvanian to Late Mississippian age (Skipp,

Hoggan, and others, 1979) for the member. Only

base of member is in quadquadrangle, but a total

Bluebird Mountain and Arco Hills Formations, undivided

(Upper Mississippian) -- Bluebird Mountain Formation

consists of very light to medium gray, very fine-

to fine-grained, chiefly calcareous sandstone and

rind, interbedded similarly colored sandy or silty

limestone, and minor light-gray chert in thin beds

and commonly forms ledges. Conodonts and calcar-

Bluebird Mountain Formation overlies conformably

a thin, chiefly covered, interval of brownish-gray

to olive-black, calcareous laminated mudstone of

Formation has a sharp conformable contact with the

Surrett Canyon Formation below. Measured thickness

of the Bluebird Mountain Formation is 53.5 ft and

the Arco Hills Formation 15 ft on the east flank

of Timbered Dome a few hundred yards north of the

Medium-light- to dark-gray, medium-gray- weather-

ing, chiefly pure, variably cherty, fossiliferous

quadrangle where a combined thickness is 68.5 ft

eous foraminifers establish a Late Mississippian

Chesterian) age (Skipp and others, 1985).

the Arco Hills Formation. The Arco Hills

Surrett Canyon Formation (Upper Mississippian)--

limestone that is altered to jasperoid in

siltstone that weathers with thin light-brown

and lenses. Formation is thin- to medium-bedded

thickness of 2,200 ft was measured less than 1/2

limestone chiefly altered to jasperoid along the

northeast border of quadrangle. Contains minor

SEDIMENTARY ROCKS

Bloom Member of Snaky Canyon Formation Upper

direction. Unconformably overlain by volcanics of

than 10 percent of unit. The unit is thick bedded

much as 10 in. (25 cm) in length, but most less

and argillite, are in a matrix of light-gray

calcareous. Both matrix-supported and clast-

welded parts of the ash-flow tuffs and the lava

flows locally form ledges; airfall tuffs and areas

of alteration form slopes. Thickness ranges from

crystalline, locally felty matrix. Light-colored

rich. Thin lava flows have phenocrysts and

those in the ash-flow tuffs set in a finely

matrix and local abundant pumice and volcanic

brown, grayish red and grayish green, and contain

chiefly crystals of plagioclase and pyroxene in

hornblende and biotite in the upper tuffs. Both

lithic fragments. Black vitrophyres and eutaxitic

are rare. The tuffs weather mostly moderate brown

and dark yellowish brown, but some are medium dark

structures are common, and xenolithic sandstone

fragments are present in places. Small vesi cles

exposed fined-grained biotite granite porphyry

younger than indicated on correlation chart

lava flows, and minor epiclastic volcanic

Tuffs of Antelope Creek and granite porphyry of

orthoclase, plagioclase, quartz and biotite in a

fine-grained groundmass of orthoclase, plagioclase

and quartz. Accessories are zircon, magnetite and

embayed. Monzonite is present only in west fork

Creek Formation (Mmg), and near the Reliance Mine

description from Anderson (1947, p. 456). May be

yellowish gray coarse-grained porphyritic

where unaltered, and light gray to yellowish gray

Thickness ranges from 115 ft to about 1,300 ft in

quadrangle to north (Skipp, 1988). Included in

this unit are small intrusive bodies of similar

composition near the mouth of Price Canyon, the

head of the left fork of Hammond Spring Creek, and

Overlies or intrudes tuffs of Antelope Creek (unit

in areas of argillic alteration. Unit consists of

numerous flows that are not mapped separately, and

locally are present; flow banding is common; unit

chiefly fine- to medium-grained, spiculitic, silty limestone that typically weathers with a thin, light-gray to light-olive-gray rind. Silty limestone is altered to jasperoid on the east flank of Timbered Dome. A few thin, noncalcareous siltstone beds are present in the basal few meters. Lower nonfossiliferous beds form steep slopes covered with silty chips; upper laminated beds are poorly exposed but contain a few brachiopods, bryozoa, and some crinoid debris. No diagnostic faunas were recovered from this unit, but foraminifers and conodonts from the formation in the Lost River Range north of this quadrangle indicate a Late Mississippian (Meramecian) age (Mamet and others, 1971; Sandberg, 1975). The basal contact is gradational with the McGowan Creek Formation. Measured thickness on the east flank of Timbered Dome on the Grouse thrust plat is 508.5 ft. An estimated thickness on the east flank of hill 7696 on the east side of Dry Fork is

double that, or about 1,000 ft McGowan Creek Formation (Upper(?) and Lower Mississippian) -- Chiefly fining upward sequence of turbidites consisting of graded beds of conglomerate through mudstone and minor limestone. The uppermost 370 ft consist of grayish-black to medium-gray, chiefly fissile laminated mudstone that weathers light to dark gray, yellowish brown, and olive gray at Timbered Dome. Near Martin, some granule- to pebble- conglomerate and pink or purple limy siltstone is present in this interval. In the middle 1,287 ft at Timbered Dome, mudstone is interbedded with varicolored, thin-bedded siltstone, pale-red, olive-green, light-brown, and pale-yellowishbrown, medium- to thick-bedded, chiefly calcareous, very fine grained sandstone, and minor medium- to dark-gray, medium-bedded, aphanitic limestone. The limestone interval, 54 ft thick, is 775 ft above the base of the formation. The basal 340 ft consist of medium- to dark-gray interbedded siltstone, dark-gray siliceous fine-grained sandstone, conglomeratic sandstone and granule-topebble conglomerate. Conglomerate clasts are chiefly chert and quartz fragments as large as 1/4 in. (7.5 mm) in diameter, and subangular to subrounded in shape. Matrix supported textures and flute casts are common. Sandstones and conglomerate weather medium gray and pale yellowish brown; some have weathering rinds. Siltstones weather light gray. Trace fossils of the Nereite association and rare wood impressions are the only fossils found in the lower one-third of the formation. The upper two-thirds contain brachiopods, Leiorhynchoidea polypleura (Girty), Echinocoelia pilosa (Girty), Quadratia eurekensi (Walcott), Orbiculoidea sp., and Rugosochonetes? sp., and the gastropod Mourlonia sp. (Mackenzie

ordon, Jr., written commun., 1982; 1988) in addition to the trace fossil Nereites association that indicates an oxygen-poor depositional environment (Ekdale and Mason, 1988) possibly at abyssal to bathyal depths (Seilacher, 1978). The brachiopod fauna resembles that reported from the Moorefield Shale (Oklahoma) of Late Mississippian (Meramecian) age. However, middle Osagean (Earl Mississippian) conodonts were identified from the limestone of the measured section by R.G. Stamm and B.R. Wardlaw (written commun., 1989), and ammonoids of the genus <u>Pericyclus</u> (<u>Stenocyclus</u>) sp. collected by Ross (<u>Nelson</u> and Ross, 1969, 970, locality 7) suggest an Osagean age for mudstones from the middle part (MacKenzie Cordon r., written commun., 1988). The brachiopods there fore, are interpreted to be mostly of Early Mississippian age in this section. The McGowan Creek Formation has been dated as entirely of Early Mississippian age on the basis of conodonts in the Lost River Range to the north (Sandberg, 1975), but some Upper Mississippian beds may be present in this area. The lower contact with Devonian rocks is disconformable. Measured total thickness is 1,997 ft on the south flank of

Timbered Dome and outcrop width indicates the formation thickens rapidly to the west. An erroneous thickness of 980 ft previously was reported for the upper member of the McGowan Creek Formation, the combined middle and upper parts of the formation in this report, in the Timbered Dome area (unit Mmgu of Skipp, 1988); the correct measured thickness is 1.617 ft. A conodont alteration index (CAI) value of 4 was obtained on conodonts from the limestone at Timbered Dome (R.G. Stamm and B.R. Wardlaw, written commun., Little Copper Member of Copper Basin Formation (Lower Mississippian) -- Interbedded quartzite, argillite. and minor conglomerate. Quartzite is light gray or white to medium gray, fine grained, impure, thick bedded, locally banded, and ledge forming. Argillite is dark gray or black, typically weathers light gray or moderate brown and forms blocky talus. Both quartzite and argillite are brecciated locally. Thin lenses of granule- to pebble-conglomerate containing subangular to

subrounded black chert pebbles as much as 3/4 in (2 cm) in diameter are present locally. No fossils were observed in this unit. Lithologies resemble those of the lower part of the Little Copper Member of the Copper Basin Formation of Kinderhookian (Early Mississippian) age (Paull and Gruber, 1977; Dover, 1981). Estimated minimum thickness for this unit is 1,000 ft. Neither top nor bottom are present Picabo Formation(?) (Upper Devonian) -- Medium light- to dark gray, chiefly fine-grained, medium- to thickbedded. locally silty or sandy laminated dolomite and minor dolomitic fine-grained sandstone. Dolomite weathers medium dark gray to light gray and light olive gray. Sandstone weathers medium dark gray to olive gray. Base not exposed. Measured thickness on the south flank of Timbered

Dome is 295 ft (90.5 m). Conodonts from the upper part of the section indicate a latest Devonian Famennian) age (Sandberg and others, 1989). The identity of the formation is questioned because the Picabo Formation at its type section chiefly consists of dolomite conglomerate and dolomitic Sandstone, though some laminated sandy dolomite is interbedded with quartzitic sandstone in the lower part (Skipp and Sandberg, 1975). Although the type section of the Picabo is nonfossiliferous, it is presumed to be very late Devonian in age on the basis of its stratigraphic position. A CAI value of 3 was determined for conodonts of this outcrop (C.A. Sandberg, written commun., 1989) Sedimentary rocks undivided (Devonian through Ordovician) -- Quartzite, sandstone, and dolomite. Includes rocks of units Dp, Of, Ok, and Os, Silurian rocks if present, and possibly Proterozoic rocks. Thickness estimated to be

about 6,000 ft. Used only on cross section Fish Haven Dolomite(?) (Middle Ordovician) -- Brownish gray, medium crystalline dolomite. Only about 6 ft (2 m) exposed in core of tight syncline in isolated block in basalt of Snake River Group along southeastern edge of quadrangle. Conformable contact with quartzite below. May be part of Summerhouse Formation Kinnikinic Quartzite(?) (Middle Ordovician)--Quartzite, light- to medium-gray, and pale-brown chiefly fine- to medium-grained, some coarsegrained, moderately well sorted, pure, silica cemented, medium- to thick-bedded, commonly laminated: weathers vellowish brown and reddish brown. About 50 ft (15 m) of section is present between dolomitic rocks in isolated hill near

eastern edge of quadrangle. Conformable contact with dolomite below. May be part of Summerhouse Summerhouse Formation (Lower Ordovician) -- Mediumlight-gray, microcrystalline, partly sandy dolomite. Uppermost 6 ft (2m) exposed in core of anticline in isolated hill near eastern edge of

Paleozoic and Precambrian rocks of the quadrangle are parts of at least two major Mesozoic Cordilleran thrust plates, the Copper Basin plate on the west, and the Grouse plate on the east (fig. 1) emplaced from southwest to northeast, probably during mid-Cretaceous time, in the southern White Knob and Pioneer Mountains of south-central Idaho. The Copper Basin thrust, the boundary thrust of the Copper Basin plate (Skipp and Hait, 1977), juxtaposes Lower Mississippian clastic rocks of the Little Copper Member of the Copper Basin Formation against Upper Mississippian limestones of the Middle Canyon Formation and Upper(?) and Lower Mississippian clastic rocks of the McGowan Creek Formation just south of Lava Creek in the southwestern part of the quadrangle. No fossils have been found in rocks of either the footwall or hanging wall in the Martin area, where a Tertiary transverse fault has offset the Copper Basin thrust Paleozoic rocks in the footwall of the Copper Basin thrust

make up most of the quadrangle and constitute the Grouse thrust plate above the buried Grouse thrust. The Paleozoic rocks are part of a large northwest-trending and northeast-verging complex anticline that resembles a fault-bend fold formed above a frontal ramp in the Grouse thrust below. The steep (60°) northeastern limb of the fold makes up the east flank of Timbered Dome. Two outcrops of Devonian and Ordovician rocks south of Timbered Dome indicate that rocks at least that old are in the core of the anticline. West of the steep northeastern limb, beds on the crest of the anticline are also folded and faulted, but they dip less steeply. Beds that dip about 30° northeast on the southwest flank of Timbered Dome are shown to constitute the hanging wall of an antithetic east-dipping thrust fault, the Champagne Creek thrust. Beds in the footwall of the Champagne Creek thrust are tightly folded about north-southtrending axes and some folds appear to be west verging. West of these tight folds in the McGowan Creek Formation, younger limestone is west-dipping to relatively flat-lying in the vicinity of Dry Fork Creek.

The McGowan Creek Formation in the footwall of the Champagne Creek thrust is a more westerly facies than equivalent beds on Timbered Dome; the shales and siltstones of the upper part of the formation contain interbedded granule conglomerate Lower Mississippian strata thicken westward from about 2,000 ft of McGowan Creek Formation on the east flank of Timbered Dome in the Grouse thrust plate to more than 11,000 ft of Copper Basin Formation in the Copper Basin thrust plate in the type area about 15 mi west of Timbered Dome (Paull and others, 1972; Skipp and others, 1979). Some stratigraphic thickening is probably present in this quadrangle from east to west as suggested on the cross section, but the McGowan Creek also may be structurally thickened in the Dry Fork Creek area.

Three periods of Tertiary extension followed Mesozoic contraction: 1) post-thrusting and pre-Challis; 2) syn-Challis; and 3) post-Challis. Faults of the first period trend east-west and cut Paleozoic rocks west of Dry Fork, but do not generally extend into Challis rocks. These faults represent at least a local period of north-south extension that followed thrusting, but preceded the Challis magmatic episode. A syn-Challis extension direction of N. 20° W. to S. 20° E. is indicated by N. 700-850 E. trends of late-stage Challis rhyolite dikes throughout the White Knob Mountains (Nelson and Ross, 1968, 1969, 1970). A few late-stage Challis dikes have this northeast orientation in the southwestern part of this quadrangle, but most trend in north-south (Champagne Creek area) or east-west (Lava Creek) directions. A mosaic pattern of faulting is described by Anderson (1929, 1947) in the volcanic rocks of the Challis Group that he attributes to domal extension above a rising granitic magma. These faults largely were observed underground and are difficult to recognize on the surface, but are considered here to be syn-Challis in age. Post-Challis extension is well-represented in the quadrangle. Most Challis Group-Paleozoic sedimentary rock contacts are faults. Only in the vicinity of Poison Gulch and Champagne Creek do Challis Group rocks unconformably overlie the McGowan Creek Formation. Younger Miocene volcanic rocks above Challis Group rocks are faulted down to the east into the Snake River downwarp, and tuffs of the Heise Volcanic Field may have been deposited against fault scarps that offset older Miocene tuffs of the Idavada Group (secs. 7, 8, and 17-20 T. 3 N., R. 25 E.). Black Cap in the southwesternmost corner of the quadrangle and the vents northwest of it are aligned in a N. 30° W. direction, parallel to and a part of the latest Pleistocene

Great Rift volcanic rift zone (Kuntz and others, 1988). The

Great Rift is a product of northeast-southwest extension that

axis of the Snake River Plain, and coincides with the Holocene

extension direction recorded by recent seismic activity in

postdates major basaltic volcanism along the northeast-trending

south-central Idaho. MINERAL AND ENERGY RESOURCES Much of the Lava Creek Mining District is contained within this quadrangle (fig. 1). The entire Champagne Creek subdistrict and part of the Lava Creek subdistrict are present. Known mineral deposits are epithermal veins and stockworks of veinlets in highly altered rocks of the Challis Group. There are veins and replacement bodies in Paleozoic rocks just to the west and south of the quadrangle. Some of the jasperoid bodies in Paleozoic rocks may have associated precious metal deposits. Silver was produced from the Champagne Creek subdistrict in 1884 to 1886 when oxidized enriched silver ores from near the surface were exploited (Anderson, 1929, 1947). In the mid-1940's improved mining methods permitted extraction of lead and zinc from primary sulphide ores from the same mines (Anderson, 1947). In recent years, several companies have prospected and tested the Champagne Creek area, and, in 1988, the Bema Gold Corporation of Canada put in a pilot heap leach test at the Champagne mine location indicated on the map. Bema Gold reports that as of July 1989, an oxide ore body containing 2.4 million tons of mineable reserves grading 0.038/short ton gold equivalent had been defined and that year-around gold and silver production began in June 1989. Further exploration along strike or additional oxide reserves and for deeper sulfide targets is continuing (Engineering and Mining Journal, 1989). The epithermal mineral deposits of the Lava Creek distric were formed by the deposition of metals from circulating hot ore-bearing solutions in open fractures during two periods of early Tertiary extension, both of them probably post-Challis (Anderson, 1929, 1947). A pilot rock geochemical survey of the district, initiated as a part of this study, confirmed scattered anomalously high Ag, Pb, Zn, and As values in andesite flow rock and tuffs of the Challis Group. A few Au anomalies also were identified in the same rocks (Hillier and others, 1983). The general north-south trend of the dike swarm west of Champagne Creek is the same as the trend of the mineralized fissures observed by Anderson (1929, 1947) and the orientation of the major ore bodies of the Champagne mine in the volcanic rocks in the Champagne Creek subdistrict. Anderson (1929, 1947) attributed this locus of mineralization to the presence of an underlying stock that shattered overlying volcanic rocks during its intrusion forming a mosaic type fault pattern. An underlying Tertiary stock may be present at depth, but random shattering above an intrusive body, even a north-south trending intrusive body, does not seem sufficient to account for the locally consistent north-south trend of dikes, mineralized fissures, oxidized ore bodies, and local faults in the Eocene tuffs and flows of the Champagne Creek subdistrict. A preexistant structural fabric is necessary. Such a fabric is present in the Mesozoic contractional fold axes and axial-plane cleavage in the disturbed Paleozoic rocks of the footwall of the antithetic Champagne Creek thrust beneath the volcanics; axes and cleavages are oriented generally north-south rather than northwest as on other parts of the Grouse thrust plate and the Copper Basin plate west of this quadrangle (Skipp and Bollmann, in press). An alternative hypothesis for the formation of north-south oriented dikes and veins therefore is that the Mesozoic contractional structural fabric in the Paleozoic rock yielded during Tertiary extension to form north-south trending open fractures. These fractures channeled metal-bearing solutions from an underlying stock and controlled fracture orientation and ore deposition in the overlying volcanic rocks Mineralized fissures in the Lava Creek subdistrict trend nearly east-west, at right angles to those in the Champagne subdistrict. The volcanics overlie rocks of the Copper Basin thrust sheet that have been transported eastward on a Cenozoic transverse fault. An east-west structural fabric parallel to this local transport direction may have developed in the massive sandstones and argillites of this part of the thrust plate. Hydrothermal alteration has affected large areas of volcanic rocks in the Lava Creek district, bleaching them nearly white. Large areas of alteration (stipple pattern overlay on the map) are characterized by kaolinization, sericitization, chalcedonization, pyritization, and local alunitization (Anderson, 1929, 1947). The ore deposits of the Champagne Mine are shallow epithermal or hot springs deposits localized in hydrothermal breccia zones, and vein deposits in the Lava Creek subdistrict may represent intermediate levels of an epitheral system (Moye and others, 1989) The presence of the stock of hornblende diorite of Little Cottonwood Creek on the southern border of the quadrangle, a petrologically similar small andesite pipe one mile north of the quadrangle (Skipp, 1988), the quartz monzonite intrusion in Hammond Spring Creek, the mosaic fault pattern in volcanics of the Champagne Creek area recognized by Anderson (1929, 1947). the north-trending rhyolite dike swarm, and a north-northeast trending magnetic high surrounded by magnetic lows in the Champagne Creek area north of Poison Gulch (Worl and others, 1989, pl. 2) all suggest the presence of an underlying magnetic body at depth, possible a stock, in the Lava Creek district. In addition, Anderson (1947) mapped a very fine grained intrusive biotite granite porphyry between Champagne Creek and Lava Creek that is included in porphyritic volcanic rocks of unit Tta on New geochemical studies indicate a potential for precious metal deposits in the Paleozoic rocks of this quadrangle. Geochemical analyses of nine samples of jasperoid and jasperoid breccia in the Timbered Dome area showed elevated concentrations

of some metals with strong associations of As-Sb-Hg-Cu-Pb-Zn and

Ag-T1 (Soulliere and others, 1988). These associations indicate

that metal-bearing solutions were present in the Timbered Dome

area also, and may have formed precious metal deposits in the vicinity of the jasperoids and jasperoid breccias. Also, a drainage-basin geochemical study using sagebrush and heavy mineral concentrates yielded preliminary evidence for local

sediment-hosted gold in the mudstones, siltstones, and sandstones of the McGowan Creek Formation and defined a precious metal anomaly in a fault breccia near a small dacite porphyry intrusion in NE1/4 sec. 24, T. 3 N., R. 24 E. (Erdman and others, 1988; Erdman, Moye, and Theobald, 1989) The thrust plates for which conodont color alteration indices (CAI) were measured in this quadrangle have slightly different thermal histories, but all of them indicate a very low potential for liquid hydrocarbons. Known oil production

generally is from rocks with alteration indices of less than Dry gas (methane), however, can be produced from rocks with indices as high as 4 to 4.5 (Epstein and others, 1977). CAI values from Timbered Dome in the Grouse plate are 2-4 indicating maximum temperatures in the range of 2000-300 °C. CAI values from limestones of the Copper Basin plate 3 miles west of this quadrangle are 4.5 (John Repetski, written commun., 1979) indicating that rocks of the quadrangle have no potential for liquid hydrocarbons and a borderline potential for dry gas. Evidence of Pleistocene geothermal activity is present in the small travertine deposit on Ordovician rocks surrounded by Snake River Group basalt, and in latest Pleistocene volcanic activity along the Great Rift zone that extends into the southern part of the quadrangle. The southern part of the quadrangle therefore has a potential for geothermal energy as well as renewed future volcanic activity.

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GEOLOGIC MAP OF MACKAY 4 (GROUSE) SE QUADRANGLE, BUTTE COUNTY, IDAHO Betty Skipp, M. A. Kuntz, and L. A. Morgan

CHAMPAGNE CREEK THRU 4000 DOS DOS

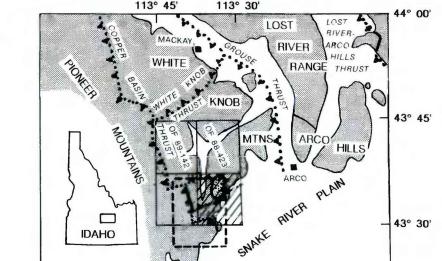


FIGURE 1. Index map of south-central Idaho showing location of Mackay 4 (Grouse) SE quadrangle (diagonal lines) in relation to Mackay 4 (Grouse) NE (Skipp, 1988), Mackay 4 (Grouse) NW (Skipp, 1989), the Grouse 15' quadrangle (solid outline), thrust faults (modified from Skipp, 1987), the Lava Creek mining district (dashed outline) (Anderson, 1929, 1947), and the Champagne Creek subdistrict (stippled).